FOUNDATIONS

The Construction and Uses of Wood, Steel and Concrete Piles

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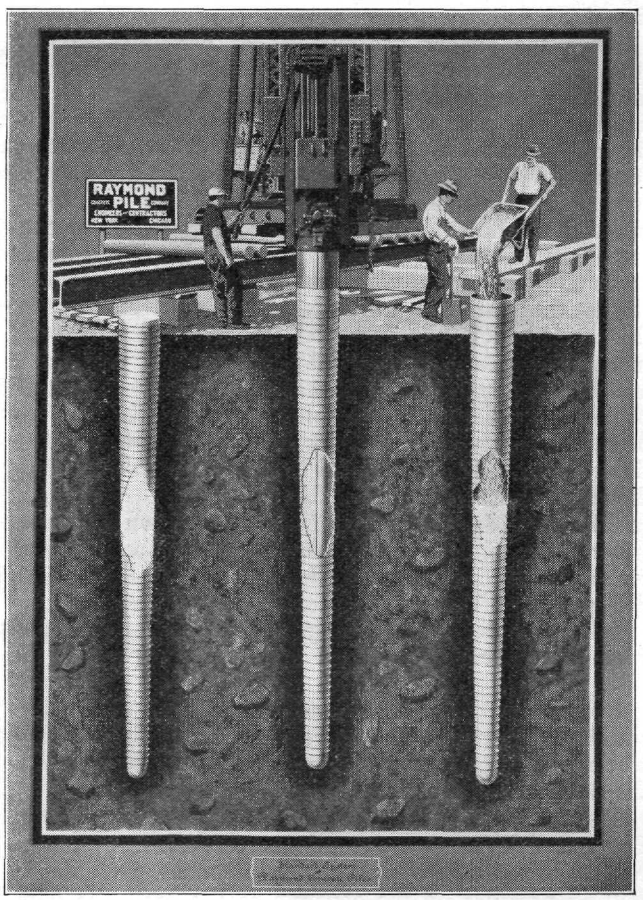
THE bearing power of soil is a controlling factor in the design of a building or bridge upon which it is to stand. If this is not known the usual procedure may be to dig test pits, drive a test rod or make augur borings. From the results of either of these methods an estimate may be made as to what the safe bearing power of the soil may be.

Suppose, however, that these tests indicate a soft strata of soil not capable of resisting a normal load.

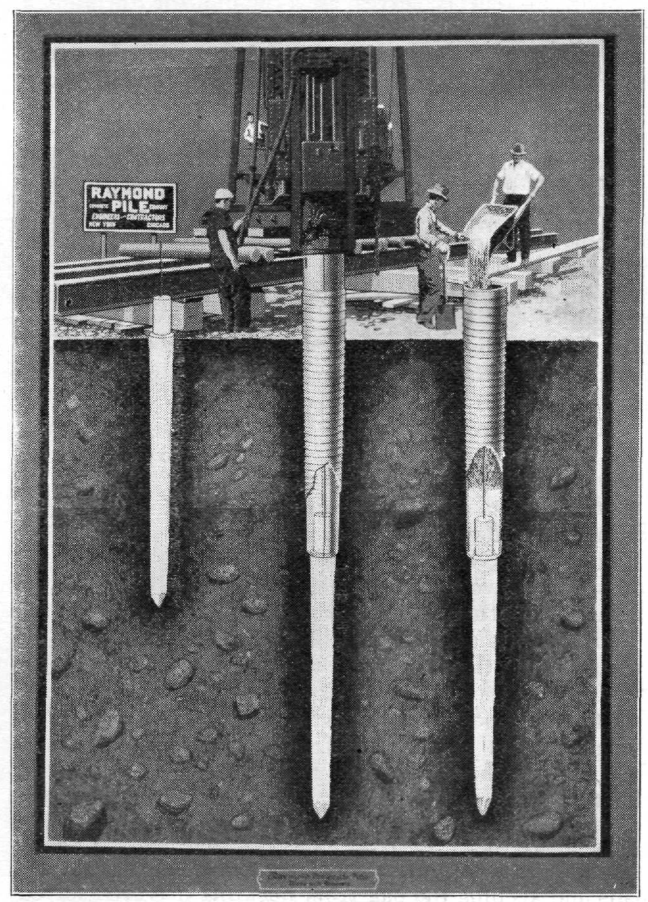


STANDARD CONCRETE PILES

In this instance a plain foundation might not be economically placed without an excessive area of footing for a normal load from the superstructure. Excavation of this non-resisting soil to a firmer one may be a theoretical possibility but economically and practically not so, and other means must be resorted to, to carry the load through this pervious layer of material.

Wood piles have long been used as a means of transferring the load through a non-resisting pervious strata to a firm soil or bed-rock beneath the surface. These wood piles are merely trees which have been cut down and trimmed close, ranging in size from 8 inches at the point to 12 or 15 inches at the head. They have been placed successfully to depths greater than one pile length by splicing. This is done by means of a dowel placed at the joint, by metal bars spiked on, or by a collar. Wood piles deteriorate when placed in certain kinds of soil and as a result are not used for every foundation.

A footing of reinforced concrete placed in the soil vertically to bed rock is sometimes used as a foundation. It is usually placed by the caisson process. Caissons are used extensively in work involving excavation under water. Compressed air is used in the caisson and the excavators work under air pressure. This forces any water out which would tend to seep in, making excavation possible. Caissons are built on the surface of the ground. They are similar to a funnel turned upside down—that is, it is hollow underneath in the center with a cutting edge on all sides, and is usually rectangular or square in shape. As the caisson sinks into the ground due to excavation in the air chamber beneath, addi-



COMPOSITE PILES

tional heights are added to the top above the ground thereby adding sufficient pressure to force it downward.

Concrete Piles are frequently used and for over a score of years have been successfully placed. There are three outstanding types of concrete piles today, notably: The Raymond Concrete and Composite Pile, The MacArthur Compressed Straight Shaft and Pedestal Pile and The Simplex Pile.

The Raymond Concrete Pile is placed by driving a tapered steel mandrel which is 8 inches in diameter at the point and increases in diameter 0.4″ per foot of length with a maximum length of 37'-6". This core or mandrel is encased in a spirally reinforced sheet metal shell of 8-foot lengths, slightly overlapping each other, from the point to the top, and hung in the leaders of the pile driver. The core with the shell is driven to a proper penetration with a 5,000-lb. steam hammer falling 3 feet. The peneration of the core per blow to resist a particular load being computed from the Engineering-News formula for steam hammer:

$$L = \frac{2\ wh}{s = 0.1}$$

where w = weight of hammer in pounds,
h = fall of hammer in feet for the last blow,
s = penetratio nof pile in inches under the last blow,
L = bearing load in pounds.

When the proper penetration has been reached the core is collapsed and withdrawn leaving the shell in the ground. Glancing down into the shell makes it possible to determine if any ground water has seeped into the shell or if there are any defects in the shell caused by driving. The spirally reinforced shell is now ready for concrete and it is poured in. The shell offers advantages in that is serves as a mould for forming a tapering pile when the concrete is placed in it. It prevents the surrounding soil from mixing with the green concrete and keeps out the excess moisture which is in the soil. It keeps the ingredients of the concrete intact while setting takes place.

The spiral reinforcement the entire length of the shell aids in that it keeps the surrounding soil in place when the core is withdrawn. It also maintains the shape when not filled with concrete while adjacent piles are driven. furthermore it acts as reinforcement against the surrounding soil until the concrete has reached its maximum strength.

In order to determine the stability of these piles under loads actual tests have been made. These are made by building a platform on a single pile and loading with a suitable, convenient material as sand, cement, rails. etc. The test pile is usually subjected to a test load twice the normal carrying capacity of the pile. Readings taken on the pile before and after loading determine the actual settlement, if any, of the pile. As a result of many tests varying from 80,000 to 140,000 pound loads there have been settlements of a small fraction of an inch and often no settlements at all.

Certain soils of a very plastic nature require a pile of greater length than the standard Raymond Pile and what is known as the Raymond Composite Pile is used. In this type a wood pile is first driven to the surface of the ground; a vertical reinforcing rod is anchored in the head of the wood pile and the head doweled off about 18 inches in length and 9½ inches in diameter. On top and over the dowel a special core fits tightly which drives the pile down further. This core is fitted with a spirally reinforced steel shell similar to the standard Raymond Concrete Pile and this shell remains in place in the soil. Fitting tightly over the head of the wood pile, it makes a sung joint between the wood pile and the concrete so that it is water tight. This tends to keep out any foreign material which might disintegrate the wet concrete as it is put in place. The steel reinforcement aids in maintaining a perfect bond between the wood and concrete during any possible earth pressure variations.

A test was recently made on a Composite Pile where the length of the wood pile was 43 feet and the concrete pile 12 feet; a total of 55 feet. The wood pile was driven to the ground level with 90 blows of a steam hammer weighing 5,000 lbs. and falling 3 feet at the rate of 60 blows per minute. Following the wood pile the steel composite core was driven with 565 blows for the 12 feet. This pile was tested shortly after with a test load of 103,000 lbs. and a total settlement of 0.453 inches was observed. This load was greatly in excess of the allowable load per pile used in the design.

As an example of the use of these piles the Statler Hotel, Buffalo, N. Y. and Forbes Baseball Field Grandstand at Pittsburgh, Pa., were built upon Raymond Concrete Piles. The Power House at the River Rouge plant of the Ford Motor Co., Detroit, Mich., was built upon 6,800 Raymond Composite Piles.

The MacArthur method of placing the pile consists of driving a steel pipe casing 16 inches diameter and one-half inch thick inside of which is a core. The core is also a steel point and enlarged cast-steel head. This appangement is set up in the leaders of the pile driver and both driven together. The driving is done according to the Engineering-News formula, heretofore mentioned.

When the proper penetration has been reached the core is withdrawn and a batch of concrete is poured into the casing filling approximately one-fourth of the depth. The core is re-inserted in the casing and resting on the concrete the casing is withdrawn about two feet as shown in the cut. The core is driven down again forcing the concrete to spread. This forms a bulb or pedestal as shown. The core is withdrawn, more concrete inserted until the casing is filled. Pressure is again applied to the core resting on the concrete, and slowly the casing is withdrawn. The pressure forces the concrete into the space left by the casing, thereby insuring a greater size of pile with a bond between it and the surrounding soil. Great adhesion, the advantage of this type of pile, is possible between particles in the mass due to pressure, thereby forming a more substantial column. This is helpful in that other piles may be driven adjacent to it without distorting it.

When the MacArthur Pile is driven and much ground water is encountered a cast iron point or shoe is placed on the lower end of the casing before it is driven into the ground. This seals the casing from any moisture which may enter while driving. It remains in the ground when the concrete is poured and forms a part of the pile.

Excavations have been made to a depth of 22 feet showing the vertical shafts to be perfect; having a cross-section of 17½ inches instead of 16 inches, which is the diameter of the pipe casing.

The MacArthur Straight Shaft Pile differs from the Pedestal Pile in that the pile is vertical from top to bottom with no pedestal. This is made possible by putting pressure on the concrete as the casing is withdrawn, but not driving the core as mentioned for the Pedestal Lile.

The MacArthur Composite Pile consists of a wood pile below the water line with a pedestal or straight shaft pile on top of that. In placing the composite pile the steel casing is driven its entire length into the ground. This usually takes the bottom of it below the water line. The core is lifted out, a wood pile is then inserted in the steel casing and this is driven its entire length below the casing as far as possible. This places the wood pile below the ground water line. Concrete is then placed in the casing on top of the wood pile and standard MacArthur Straight Shaft or Pedestal Pile may be formed. By driving the casing first and the wood pile down through the casing there is less opportunity for the wood to be thrown out of alignment by any obstruction. This is possible due to the casing acting as a guide for the wood pile follower.

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As an example of use of this type of piles, the Administration building of the Willys-Overland Co. of Toledo, Ohio, is built on MacArthur Pedestal Piles while the General Machine Shop at the U. S. Navy Yard, Washington, D. C., is built upon the MacArthur Straight Shaft Concrete Piles.

The Simplex Pile is placed by driving a cylindrical steel tube 16 inches in diameter and three-fourths inch thick, at the bottom of which is placed a conical cast iron point. This steel tube is driven by means of a 3,000-lb. drop hammer. When proper penetration has been reached the tube is filled with concrete and the tube is withdrawn. As the tube is withdrawn concrete is forced by its own weight into the opening left by the pipe. This affords a vertical pile creating an effective end bearing with some skin friction in addition. The Simplex Piles have been placed to a depth of 75 feet with working loads on the piles being generally 30 tons per pile.

The Pennsylvania R. R. Track Elevation of the Conemaugh Division, North Side, Pittsburgh, Pa., was constructed on 4,000 piles and in the construction of the B. & O. Train Elevator at Locust Point, 7,000 piles were used; these being two instances where this type of pile was used.